No. 91-860

In the Supreme Court of the United States

OCTOBER TERM, 1991

UNITED STATES DEPARTMENT OF COMMERCE, ET AL.,
APPELLANTS

v.

STATE OF MONTANA, ET AL.

ON APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF MONTANA

JOINT APPENDIX
(Volume I)

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NOTICE OF APPEAL FILED: OCTOBER 24, 1991
APPEAL DOCKETED: NOVEMBER 26, 1991
PROBABLE JURISDICTION NOTED: DECEMBER 16, 1991.

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IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MONTANA
HELENA DIVISION

CV 91-22-H-CCL

THE STATE OF MONTANA; STAN STEPHENS, Governor of the State of Montana; MARC RACICOT, Attorney General for the State of Montana; MIKE COONEY, Secretary of State for the State of Montana; MAX BAUCUS, United States Senator; CONRAD BURNS, United States Senator; PAT WILLIAMS, United States Representative; and RON MARLENEE, United States Representative, PLAINTIFFS

v.

UNITED STATES DEPARTMENT OF COMMERCE; ROBERT A. MOSBACHER, Secretary of the United States Department of Commerce; BUREAU OF THE CENSUS; BARBARA EVERITT BRYANT, Director of the Bureau of the Census; and DONNALD K. ANDERSON, Clerk of the United States House of Representatives, DEFENDANTS

RELEVANT DOCKET ENTRIES

DATE	NR.	PROCEEDINGS
5/22/91	1	COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF W/ Attachment A (2 pages)
	—	Issued Summons to following: D. Anderson, Barbara E. Bryant, Bureau of Census, Robert A. Mosbacher, Sec., U.S. Dept. of Commerce, U.S. Dept. of Com., D. Thornburgh, U.S. Atty. General, Doris Poppler, U.S. Atty.? * * *

DATE	NR.	PROCEEDINGS
	2	Plntf's MOT FOR PRELIMINARY INJUNCTION gr
	3	Plntf's BRIEF IN SUPPORT OF MOT FOR PRELIMINARY INJUNCTION Exh. atchd.
	4	Plntf's AFFID OF KENNETH J. TIAHRT
	5	Plntf's AFFID OF DIANNA M HILL W/ atchmts
	6	Plntf's MOT FOR CONVENING OF THREE-JUDGE COURT AND SUPPORTING MEMO.
5/24/91	7	ORDER, Having reviewed Plntfs' filed papers, Crt determines that the complaint raises challenge to constitutionality of the apportionment of congressional districts, & formally alleges basis for equitable relief, making this an appropriate case for presentation to three judge court. Accordingly, Crt notified office of Chief Judge of the Ninth Circuit Court of Appeals of the filing of this action and of the request for three judge court. Copies of this order be immediately transfitted to Chief Judge J. Clifford Wallace and Terry Nafisi, Deputy Circuit Executive.
		* * * * *
7/ 5/91	17	EXECUTIVE BRANCH DEFTS' MOTION TO DISMISS
	18	EXECUTIVE BRANCH DEFTS' MOTION TO DISSOLVE THREE-JUDGE COURT
	19	MEMO IN SUPT OF EXECUTIVE BRANCH DEFTS' MTN TO DISMISS
	20	MEMO IN SUPT OF EXECUTIVE BRANCH DEFTS' MTN TO DISSOLVE THREE-JUDGE COURT

DATE	NR.	PROCEEDINGS
7/ 3/91	21	STIPULATION RE: PARTICIPATION OF DEFT DONNALD ANDERSON signed by cnsl of record.
		* * * * *
7/11/91	24	Pltf's MEMO BRIEF IN OPP TO MTNS TO DISMISS & TO DISSOLVE THREE-JUDGE COURT
7/17/91	25	REPLY BRIEF IN SUPP OF EXECUTIVE BRANCH DEFTS' MTNS TO DISMISS & TO DISSOLVE THREE-JUDGE COURT
		* * * * *
	28	Plntf's SUPPLEMENTAL BRIEF IN OPPOSITION TO DFNTS' MOTION TO DISMISS
		* * * * *
8/ 7/91	30	STATE OF WASHINGTON'S AMICUS BRIEF IN SUPPORT OF THE EXECUTIVE BRANCH DFNTS' MOT TO DISMISS
8/15/91	32	ORDER, Dfnts' motion to dismiss and motion to dissolve three-judge-court are DENIED, Any order such as this may be reviewed by the full court at any time before final judgment. * * *
	33	ORDER, case is set for hearing on Plntfs' motion for preliminary injunction on Sept. 3, 91 at 9:30 am at Helena before 3 judge court comprised of Hon. D. O'Scannlain, Hon. J. Battin and Hon. C. Lovell. Crt will also hear cross-mots by parties for sum. jdgmt, should they desire to file same. * * *
		* * * * *
8/22/91	38	Pltf's MOTION FOR SUMMARY JUDGMENT
	39	BRIEF IN SUPPT OF MOTN FOR SUMM. JGMT

DATE	NR.	PROCEEDINGS
	39A	Executive Branch's MTN, FOR SJ
8/23/91	40	Executive Branch Defts' MEMO IN SUPP OF MTN FOR SJ & IN OPP TO PLTFS' MTN FOR PRELIMINARY INJUNCTION
	41	Executive Branch Defts' PETITION FOR REVIEW BY THREE-JUDGE COURT OF ORDER DENYING MTN TO DISMISS
	42	MEMO IN SUPP OF EXECUTIVE BRANCH DEFTS' PETITION FOR REVIEW BY THREE JUDGE COURT OF ORDER DENYING MTN TO DISMISS
8/28/91	45	Pltf's BRIEF IN OPP TO DEFTS' MTN FOR SJ
		* * * * *
	47	Pltfs' MEMO IN OPP TO EXECUTIVE BRANCH DEFTS' PETITION FOR REVIEW BY 3-JUDGE COURT OF ORDER DENYING MTN TO DISMISS
8/28/91	48	EXECUTIVE BRANCH DEFTS' OPP TO PLTFS' MTN FOR SJ
9/3/91	—	ENT RECORD OF PROC. AT HLNA. Hon Chas C. Lovell, Hon. Diarmud F. O'Scannlain & Hon. James Battin sitting. * * * Matter deemed submitted and crt adj.
		* * * * *
10/18/91	51	OPINION & ORDER—pltfs' mtn for sj is GRANTED & defts' mtn is DENIED as to Count I of pltfs' complaint. Judgment shall enter declaring section 2a of Title 2, United States Code unconstitutional & void & permanently enjoining defts from effecting reapportionment of the House of Representatives under the provisions of that statute. Having decided Count I in favor of pltfs & granted pltfs' request for declaratory & injunctive relief, it is unnecessary for the crt to further consider the merits of Count II.

DATE	NR.	PROCEEDINGS
	52	JUDGMENT & PERMANENT INJUNCTION—2 USC Section 2a is unconstitutional & void, the defts & each and all of them & their agents are hereby permanently enjoined from effecting reapportionment of the US House of Representatives under the provisions of said statute.
10/24/91	53	Dfnts' NOTICE OF APPEAL TO THE SUPREME COURT OF THE UNITED STATES the final order dated 10-18-91, granting plntfs perm inj & the Judgment entered 10-18-91
10/24/91	54	Dfnts' NOTICE OF APPEAL to Ninth Circuit Crt of Apls the final Jdgmt & Order dated October 18, 1991.
		* * * * *
11/12/91	55	Deft's NOTICE OF APPEAL TO THE SUPREME COURT OF THE US the final order dated 10-18-91, granting pltfs perminj & the Judgment entered 10-18-91 (deft US House of Representatives—DONNALD K. ANDERSON)
		* * * * *
	57	Deft's (US House of Rep—DONNALD K. ANDERSON) NOTICE OF APPEAL TO THE NINTH CIRCUIT COURT OF APPEALS the final jdgmt & Order dated 10-18-91
		* * * * *

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MONTANA
HELENA DIVISION

Cause No. CV91-22-H-CCL

THE STATE OF MONTANA; STAN STEPHENS, Governor of the State of Montana; MARC RACICOT, Attorney General for the State of Montana; MIKE COONEY, Secretary of State for the State of Montana; MAX BAUCUS, United States Senator; CONRAD BURNS, United States Senator; PAT WILLIAMS, United States Representative; and RON MARLENEE, United States Representative, Plaintiffs,

-*v*-

UNITED STATES DEPARTMENT OF COMMERCE; ROBERT A. MOSBACHER, Secretary of the United States Department of Commerce; BUREAU OF THE CENSUS; BARBARA EVERITT BRYANT, Director of the Bureau of the Census; and DONNALD K. ANDERSON, Clerk of the United States House of Representatives, Defendants.

AFFIDAVIT OF DIANNA M. HILL

[Filed May 22, 1991]

STATE OF MONTANA)
:
County of Lewis & Clark)

Dianna M. Hill, being first duly sworn, upon her oath deposes and says:

1. I am a Programmer/Analyst II with the Montana Department of Justice, Data Processing Division, and have been employed by the Department since August, 1990.

I have the qualifications set forth in my resume, a copy of which is attached hereto as Exhibit A.

2. In preparation for this litigation, I have reviewed the formulae reprinted in the publication of the Bureau of the Census, United States Department of Commerce, entitled *Counting for Representation: The Census and the Constitution*, attached hereto as Exhibit B.

3. During February and March 1991, I created two programs and several databases to project and compare representative apportionment using the various formulae contained in Exhibit B. My calculations were made using data from the 1990 Census provided by the Bureau of the Census, United States Department of Commerce, attached hereto as Exhibit C.

4. Initially, each state was assigned one representative, the constitutional minimum, and each of the remaining 385 representatives was assigned by determining each state's priority using the Basic Formula (described in Exhibit J). The next representative was assigned to the state with the highest priority. This process was repeated until all 435 representatives were assigned to a state, and further projected to a total of 500, similar to the data provided by the Census Bureau. Each of the representatives and the state's priority at the time of the assignment were captured at this point for later comparisons between the formulae. The priority assignments are attached hereto as Exhibits D, E, and F, representing the Hill, Dean and Adams formulae, respectively.

5. Once the data for each formula was generated, a comparison between the Hill formula and each of the other two formulae (Adams and Dean) was performed. I then extracted the data for those states which would be affected if the formula was changed. This extract, which highlights those states that would benefit or lose if the formula changed, is attached hereto as Exhibit G. These exhibits show that under the Hill formula Montana is entitled to one representative, whereas under either the Dean formula or the Adams formula Montana is entitled to two representatives.

6. Finally, I generated from this data a table listing each state by number of constituents per representative for each of the three formulae. This table is attached as Exhibit H. I wrote another program to utilize this data to calculate variability and its square root using the ideal district size, as well as the estimated variance and standard deviation using the actual district size mean, the results of which are attached as Exhibit I. Exhibit I also illustrates the range, for each method, between the congressional district with the maximum number of constituents and the congressional district with the minimum number of constituents, as well as the ideal district size based upon a total membership in the House of Representatives of 435.

Dated this 21 day of May, 1991.

/s/ Dianna M. Hill
DIANNA M. HILL

Subscribed and sworn to before me this 21st day of May, 1991.

(SEAL)

/s/ Phyllis A. Holm
Notary Public
State of Montana.
Residing at Clancy, Mt.
My commission expires 7-9-93

HILL AFF. EXH. A.

DIANNA M. HILL
PO Box 5401
Helena, MT 59604
(406) 449-8676

CAREER OBJECTIVE

A challenging and stimulating position as a System Programmer/Analyst within a progressive organization.

EDUCATION

BS, *cum laude*, Computer Science, minor in Mathematics, Monmouth College, West Long Branch, NJ, 1984

AS, Mathematics, Brookdale Community College, Lincroft, NJ 1982

Nuclear, Biological and Chemical NCO/Officer Course, Fort Jackson, SC, 1978

Power Generation Equipment Operator/Mechanic, US Army Engineer School, Fort Belvoir, VA, 1977

PROFESSIONAL EXPERIENCE

Over eight years of professional experience includes software design, development, testing and documentation; data base management; statistical analysis; personal computer course development and teaching; math and computer science tutoring; production research; and technical writing. Proficiency in Data General Assembler, IBM 360/370 Assembler, IBM-JCL, ANSI FORTRAN, ANSI COBOL, C, CICS COBOL, IDMS, PL/I, Pascal, dBase III+ query language, Clipper, and Basic. Extensive experience with the following PC software: ChiWriter, EnerGraphics, FlowCharting II+, MicroSoft FORTRAN, FoxBase +, Harvard Graphics, Lotus 123, Macro Assembler, Norton Utilities, PC Tools Deluxe, Procomm, rBASE, Scanning Gallery, Timeline, Turbo Basic, Turbo

Pascal, WordPerfect and WordStar. Hardware environments include AN/UYK-19 (ROLM 1602B), AN/UYK-64 (ROLM 1666C), DEC VAX 11/780, IBM 360/370, IBM 4381, IBM PC/XT/AT compatibiles, DEC Rainbow 100, BTI 8000, TRS-80, and Commodore 64.

CURRENT ASSIGNMENT

Programmer Analyst II for the State of Montana Department of Justice Data Processing Division assigned to support enhancements, improvements and corrections to the Motor Vehicle System. The Motor Vehicle System is a real-time computer system written in CICS COBOL which captures vehicle transactions including registration and titling entered by numerous operators at fifteen remote sites. This motor vehicle data is maintained in an IDMS database, which is updated via online transactions as well as batch processing from VSAM files captured during online processing. Further, daily batch jobs process the database information to generate various statistical, information and error reports.

PREVIOUS ASSIGNMENT

Senior Computer Programmer/Analyst for the Center for Electronic Warfare/Reconnaissance, Surveillance and Target Acquisition (EW/RSTA) assigned to the United States Army Field Artillery's Meteorological Data System (MDS) in a research and development facility at Evans Area, Fort Monmouth, NJ. The MDS is a real-time computer system written in Data General Assembler which captures pressure, temperature, and humidity telemetry data transmitted by a weather-balloon-borne radiosonde, combines the data with position location information obtained from either a NAVAID (navigational aids) Data Unit (LORAN, Omega and/or VLF transmissions), an Antenna Data Unit (Radio Direction Finder angle information), or an Auto-Theodolite (pilot balloon coordinate information). The MDS then massages the data using

meteorlogical algorithms and provides real-time meteorological data in various messages formats via a Remote Data Terminal to TACFIRE, MLRS, LANCE, and BCS as well as via teletype to standard military communications systems.

CAREER HIGHLIGHTS

Currently responsible for assisting in building a PC-based prototype of the Motor Vehicle System for offline processing at the remote sites to minimize mainframe usage where possible. This will require timed communications between the mainframe and dedicated computer or LAN server at each remote site.

Wrote and compiled the Software Product Specification for the AN/TMQ-31 Meteorological Data System, a seven-volume programmer's reference document which details top-level design, detailed design and interface design; rewrote and compiled the Computer Program Development (B5) Specification for the Meteorological Data System AN/TMQ-31 System Processor Unit; participated in the Functional Qualification Test and Performance Qualification Test during First Article Testing as a government evaluator; assisted in the correction of 75 Software Trouble Reports uncovered during First Article Testing; wrote and compiled the AN/TMQ-31 (MDS) Follow Up Evaluation Test Procedures; participated in the Follow Up Evaluation Test as a government evaluator; and wrote and compiled the AN/TMQ-31 (MDS) Follow Up Evaluation Test Report.

Designed and developed software tools to automate the development of the Software Product Specification; monitor, compare and report results of the Functional Qualification Test, Performance Qualification Test and Follow Up Evaluation; and to track Software Trouble Reports and resultant changes to the software.

Designed, tested and implemented the NIFFTE Data Base Program, NIFFTE Guard Shack Program, NIFFTE Guard Shack To Go Program, and the NIFFTE Head Shed Program. This series of data base management programs was designed to control access to a restricted research and development area by providing an automated security roster, a subset of the master data base, to computer-illiterat guards at the entry point, a master data base located at a remote site, and a means of maintaining data base integrity while updating records at both sites without networking capabilities due to security requirements. Additional utilities provided immediate solutions for fouled data at the Guard Shack during hours when support personnel were unavailable. Wrote and compiled a series of reference and user's manuals including a 6th-grade reading level Guard Shack User's Manual and a step-by-step extract detailing start-up and recovery procedures.

Designed, tested and implemented major programming changes to the SADS 6 telemetry program, a real-time mission to accept telemetry data transmitted from both the ARTIS control radar and the SADS 6 test radar, convert the data and display both graphics and comparison graphs to Vector General scopes on the ground.

Designed, tested and implemented the ALR-62I program to accept telemetry data, convert it, and produce real-time displays duplicating on-board scopes which detect, identify and track mission threats.

Designed, tested and implemented the Contract Data Requirements Schedule Program, a generic data base management tool designed to manipulate data related to contract data requirements. Wrote and compiled the Contract Data Requirements Schedule Program User's Manual.

Designed, developed and taught courses in Micro-Pro's WordStar, Ashton-Tate's dBase II and MicroSoft's Multiplan to government employees.

Designed, tested and implemented a statistical analysis package to compile student evaluations for the Departments of Sociology, Anthropology, Social Work and Criminal Justice at Monmouth College.

Tutored educationally-disadvantaged students in mathematics and computer science for the Educational Opportunity Fund (EOF) Office at Brookdale Community College.

Led a small work force in production research project at Excelled, Incorporated. Conducted, measured, and analyzed work flow and efficiencies testing. Also organized and implemented an inventory control system.

Supervised two civilian and three military personnel in a headquarters office in the US Army. Was responsible for all incoming and outgoing military correspondence, military filing system, military criminal justice proceedings at company level and unit level mail room. Was one of four Nuclear, Biological and Chemical (NBC) Team members at brigade level. During semi-annual NBC alerts, assisted in data collection and analysis, radio communications and team mobilization.

WORK EXPERIENCE SUMMARY

State of Montana Department of Justice, Helena, MT—.8 year

UNISYS Defense Systems, Eatontown, NJ—5.2 years

Vanguard Technologies Corporation, Eglin Air Force Base, FL—.7 year

Monmouth College, West Long Branch, NJ—.3 year

Brookdale Community College, Lincroft, NJ—2.5 years

Excelled, Incorporated, Edison, NJ—1.5 years

US Army, Fort Jackson, SC—3 years

HONORS

UNISYS Achievement Award for Excellence, Eatontown, NJ, 1988

Mu Kappa Sigma Honor Society, Monmouth College, West Long Branch, NJ, 1984

Lambda Sigma Tau Honor Society, Monmouth College, West Long Branch, NJ, 1984

Mathematics Honor Society, Monmouth College, West Long Branch, NJ, 1984

Distinguished Graduate, Nuclear, Biological and Chemical NCO/Officer Course, Fort Jackson, SC, 1978

Distinguished Graduate, Power Generation Equipment Operator/Mechanic, US Army Engineer School, Fort Belvoir, VA, 1977

Outstanding Trainee of the Cycle, Basic Training, Fort Jackson, SC, 1976

REFERENCE

Available upon request.

REPORT OF NATIONAL ACADEMY OF SCIENCES COMMITTEE ON APPORTIONMENT

(Source: Annual Report of National Academy of Sciences, Fiscal Year 1928-29, pp. 20-23)

REPORT OF THE PRESIDENT OF THE ACADEMY

In accordance with the provision of article V, section 4, of the constitution of the Academy, stipulating that in cases of requests by the Government of the United States to the National Academy of Sciences for investigations or reports by the Academy the President shall report their results to the Government as soon as obtained and to the Academy at its next following stated meeting, I beg to report that the President of the Academy has replied to a request by Mr. Nicholas Longworth, Speaker of the House of Representatives, for information with regard to the mathematical aspects of the problem of reapportionment. Upon receipt of the request the following committee was appointed to consider the matter: Raymond Pearl, chairman: G. A. Bliss, E. W. Brown, L. P. Eisenhart, and W. F. Osgood (Mr. Osgood resigning before the completion of the committee's report). The committee presented a very comprehensive report which was forwarded to the Speaker on February 5, 1929. Later, with the Speaker's informal approval, copies of the report were sent to Senator Claude A. Swanson, of Virginia, and to Senator David I. Walsh, of Massachusetts, both of whom had requested the information.

A full copy of the report, as presented by the committee and forwarded by the President of the Academy to the Speaker and to Senators Swanson and Walsh, is attached hereto.

T. H. MORGAN, *President.*

REPORT TO THE PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES

The committee appointed by you, in response to the request of the Speaker of the House of Representatives for information regarding the mathematical aspects of the problem of reapportionment, submits the following report:

The Constitution provides that, "Representatives shall be apportioned among the several States according to their respective numbers, counting the whole number of persons in each State, excluding Indians not taxed. * * * But each State shall have at least one Representative."

If fractional voting were permitted in the House of Representatives the exact number of Representatives with whole votes, and the size of the fractional vote for an additional Representative, to which each State would be entitled in a theoretically perfect apportionment could be readily calculated. It would only be necessary to work out the following proportion: The number of votes for any particular State is to the total number of votes for all States as the population of the particular State is to the total population of all States.

If, however, this simple proportionality were calculated it would result, in nearly all cases, that the number of Representatives for each particular State would consist of a whole number and a fraction, as, for example, 7.3. Fractional voting is not permitted. Therefore it is necessary to reach a solution of the apportionment problem in whole numbers. This fact alters the mathematical nature of the problem fundamentally. Even when the exact number of votes, including fractions, belonging theoretically to each State is precisely known, this knowledge is not of itself sufficient to determine the proper number of Representatives to be apportioned to that State. The proper apportionment of integral numbers of Representatives to a particular State may differ by several units from the number obtained by simple proportion. This is true regardless of which of the several known methods of apportionment described below is adopted.

The problem of apportionment which has been thus described is a problem in applied mathematics. It should be understood that frequently a problem in applied mathematics may have no unique solution, for the reason that the data initially given do not completely characterize the solution mathematically. In such cases a solution must be chosen for other than mathematical reasons among those which are mathematically possible.

There are five methods of apportionment now known which are unambiguous (that is, lead to a workable solution), and should be considered at this time.

These five methods are:

Method of smallest divisors.
Method of the harmonic mean.
Method of equal proportions.
Method of major fractions.
Method of greatest divisors.

In the present state of knowledge your committee regards these as the only methods of apportionment avoiding the so-called Alabama paradox which require consideration at this time. Their effectiveness is based upon a mathematical test which will be described below. Another method of approach to the apportionment problem may be based upon the adjustment by some method of curve fitting (as, for example, the method of least squares) of representation to the population of the country as a whole, but in the opinion of your committee the methods of this type so far proposed, which do not lead to solutions among the five listed above, fail.

After full consideration of the various methods your committee is of the opinion that, on mathematical grounds, the method of equal proportions is the method to be preferred. Each of the other four methods listed is, however, consistent with itself and unambiguous.

The essential mathematical characteristics of the five methods are as follows:

Let the population of a State be A and the number of Representatives assigned to it according to a selected method of apportionment be a, and let B and b represent the corresponding numbers for a second State. Under an ideal apportionment the population A/a, B/b of the congressional districts in the two States should be equal, as well as the numbers a/A, b/B, of Representatives per person in each State. In practice it is impossible to bring this desirable result about for all pairs of States.

In the opinion of the committee the best test of a desirable apportionment so far proposed is the following:

An apportionment of Representatives to the various States, when the total number of Representatives is fixed, is mathematically satisfactory if for every pair of States the discrepancy between the numbers A/a and B/b cannot be decreased by assigning one more Representative to the State A and one fewer to the State B, or vice versa, or if the two numbers a/A and b/B have the same property.

For the purposes of discussion let A/a be larger than B/b so that State A is underrepresented as compared with B. If the "discrepancy" between A/a and B/b is defined to be the percentage discrepancy; that is the difference $A/a—B/b$ divided by the smaller B/b of the two numbers A/a, B/b and if the discrepancy between b/B *and* a/A is measured in the same way, the test above leads to an apportionment which satisfies the test when applied to either the pair A/a, B/b, or the pair a/A, b/B. The method so determined has been called the method of equal proportions.

If the test is applied only to the pair a/A, b/B, and if the discrepancy between those numbers is interpreted to be the absolute difference $b/B—a/A$, another method of apportionment called the method of major fractions is uniquely determined. If, on the other hand, the test is applied only to absolute difference of the pair A/a, B/b a third method, called the method of the harmonic mean is similarly defined.

It has been shown that there are two further methods of apportionment determined by the test set down above when applied to the differences $b—aB/A$, $bA/B—a$. Those are called, respectively, the method of smallest divisors, and the method of greatest divisors.

The methods thus briefly characterized mathematically are the five methods in the list above. Each method in the list favors the larger States as compared with the methods which precede it. This means in the case of the second and fourth methods, for example, that if for two unequal States, A, B, the fourth method assigns more Representatives to A and fewer to B than the second method, then the State A is the larger of A and B.

The method of the harmonic mean and the method of major fractions are symmetrically situated on the list. Mathematically there is no reason for choosing between them. A similar symmetry exists for the methods of smallest and greatest divisors for which the defining discrepancies seem, however, more artificial than those for any of the other three methods.

The method of equal proportions is preferred by the committee because it satisfies the test proposed above when applied either to sizes of congressional districts or to numbers of Representatives per person, and because it occupies mathematically a neutral position with respect to emphasis on larger and smaller States.

G. A. BLISS,
E. W. BROWN,
L. P. EISENHART,
RAYMOND PEARL, *Chairman.*

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MONTANA
HELENA DIVISION

Cause No. CV91-22-H-CCL

THE STATE OF MONTANA, ET AL., PLAINTIFFS

v.

UNITED STATES DEPARTMENT OF COMMERCE, ET AL., DEFENDANTS

DECLARATION OF LAWRENCE R. ERNST

I, Lawrence R. Ernst, declare and state as follows:

BACKGROUND

1. I am Assistant Division Chief of the Statistical Research Division, Bureau of the Census (see Exhibit A for curriculum vita).

THE DECENNIAL CENSUS AND APPORTIONMENT

2. The Census Bureau conducts the decennial census to determine the whole number of persons in each state, and then calculates the apportionment of seats in the U.S. House of Representatives among the states. The calculation of the apportionment is based upon the method of equal proportions as required by Title 2, United States Code, Section 2a(a). These results are conveyed to the President through the Secretary of Commerce on or before December 31st of the year in which the census is taken (Title 13, United States Code, Section 141(b).

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3. The President then transmits to the United States Congress (the Congress) a statement of the whole number of persons in each state and the number of representatives in the Congress to which each state is entitled, as ascertained under the decennial census (Title 2, United States Code, Section 2a(a)). The Clerk of the U.S. House of Representatives (the House) then notifies each state (via a Certificate of Entitlement) of the number of representatives in Congress to which it is entitled (Title 2, United States Code, Section 2a(a)).

4. Article I, Section 2 of the Constitution further requires that "The Number of Representatives shall not exceed one for every thirty Thousand, but each State shall have at Least one Representative. . . ." The Congress has legislated four methods for apportionment since the first census of 1790. In 1941, Congress passed laws that govern the method currently used and the process for apportionment.

METHODS USED TO APPORTION THE HOUSE OF REPRESENTATIVES

5. Following the first decennial census in 1790, Congress legislated use of the Jefferson method (also known as the method of greatest divisors) of apportionment in 1792. This method was used after each subsequent census through 1830.

6. Following the 1840 census, the Congress legislated use of the Webster method (also known as the method of major fractions) for the apportionment calculation.

7. Congress legislated use of the Vinton method (also known as the Hamilton method) for apportionment following the censuses of 1850 through 1900. Under this method, it is mathematically possible that a state could be entitled to fewer seats if the size of the House were increased and the population of all states remained constant. This anomaly is known as the "Alabama paradox", because it was observed that for the 1880 census, Alabama would receive eight seats with a House size of 299

and seven seats with a House size of 300 by the use of the Vinton method.

8. In 1910, Congress legislated use of the major fractions method. Congress could not decide on an apportionment plan following the 1920 census and, as a result, no reapportionment took place. In 1929, Congress passed a law that made reapportionment automatic, beginning with the reapportionment following the 1930 census, using whatever method was used for the previous apportionment in the event the Congress did not agree on the method to be used. Thus, as a result of this legislation, the major fractions method, which had been used in 1910 (the most recent reapportionment), was used again following the 1930 census. It should be pointed out that the major fractions and equal proportions methods resulted in the same apportionment for 1930 so that Congress, in effect, did not have to choose between those two methods that had been the focus of Congressional hearings on apportionment.

9. In 1941, the Congress debated apportionment methodologies and decided that the method of equal proportions (also known as the Hill method) would be used for the apportionment based on the 1940 census. The method of equal proportions has been used for each subsequent apportionment, including 1990.

NATIONAL ACADEMY OF SCIENCES REVIEW OF METHODS

10. One of the products of the lengthy debates in the Congress regarding apportionment following the 1920 census, was the Congress' commissioning the National Academy of Sciences (NAS) to prepare a report "regarding the mathematical aspects of the problem of reapportionment". The report of the Committee on Apportionment discussed five methods "now known which are unambiguous (that is, lead to a workable solution)": smallest divisors (Adams method), harmonic means (Dean

method), equal proportions, major fractions, and greatest divisors. With a fixed House size, apportionments under these five methods are calculated using formulas involving each state's total population and a divisor which determines each state's priority for its next seat (after one seat is assigned to each state). The divisiors for the different formulas are functions of the number of seats already assigned to a given state which vary according to specific goals that each method is designed to achieve.

11. The NAS committee put forth the following tests to measure equity in assigning seats:

a) *Persons per representative* (Average district size)—Determined by dividing the population of each state by the number of representatives assigned to that state.

b) *Person's share of a representative*—Determined by dividing the number of representatives assigned to each state by the population of that state.

c) *Representation surplus*—The absolute difference between the number of representatives of an over-represented state (a state where the average persons per representative is lower than that of another state) and the number of representatives of an under-represented state multiplied by the population of the over-represented states divided by the population of the under-represented state.

d) *Representation deficiency*—The absolute difference between the number of representatives of an under-represented state and the number of representatives of an over-represented state multiplied by the population of the under-represented state divided by the population of the over-represented state.

12. The NAS committee tested equity by applying pairwise comparisons, a commonly used approach that consists of examining the effects of moving a seat between any pair of states. An apportionment method is optimal under the pairwise criterion with respect to a particular measure of inequity if a transfer of representatives be-

tween any pair of states increases the amount of inequity between these states. The measures of inequity are expressed either as absolute differences or as relative diffrences in persons per representatives or a person's share of a representative (also referred to as percent differences or proportional differences).

The absolute difference between two numbers consists of subtracting the smaller number from the larger number.

The relative difference between two numbers consists of subtracting the smaller number from the larger number and then dividing the result by the smaller number.

Paragraph 21 of this declaration provides numerical illustrations of the distinction between absolute and relative differences).

13. With the pairwise criterion, each of the five methods considered by the NAS committee is optimal for different measures of inequity. The major fractions method is optimal with respect to the absolute difference between each person's share of a representative. The harmonic means method is optimal with respect to the absolute difference between the numbers of persons per representative. The equal proportions method is optimal with respect to both the percent difference between the number of persons per representative *and* the percent difference between each person's share of a representative. The smallest divisors method is optimal with respect to the absolute representation surplus, while the greatest divisors method is optimal with respect to the absolute representation deficiency.

14. The report of the National Academy of Sciences committee, submitted to Congress in 1929, stated that the committee preferred the equal proportions method and concluded that "it occupies mathematically a neutral position with respect to emphasis on larger and smaller states" (Report of the National Academy of Sciences Committee On Apportionment from the Annual Report of

the National Academy of Sciences, Fiscal Year 1928-29, pp. 20-23).

15. In summary, since 1790, Congress has legislated use of four different methods for apportionment. Three of these methods (major fractions, equal proportions, and greatest divisors) and two others (harmonic means and smallest divisors) were studied and reported on to the Congress by the National Academy of Sciences in 1929. Attached hereto as Exhibit B is a table which displays apportionments based on the 1990 census results and a fixed House size of 435 under these fives methods and the Hamilton method. Besides these six methods, many other methods could be devised depending on the objectives to be met.

REVIEW OF METHODS AND RESULTS DESCRIBED BY PLAINTIFFS

16. Plaintiffs describe three methods for apportionment in their Motion for Preliminary Injunction: the method of equal proportions; the method of smallest divisors; and the method of harmonic means. To compare and evaluate these methods, they cite the principle of "one person, one vote" as the objective (or "test for fairness") to be met. They then propose average district size (number of persons per representative) be used to measure the extent to which any method can meet this test. Next they state that the Dean Method will always minimize the absolute difference in average district size (for pairwise comparisons of the results when deciding how to allocate a seat between any two given states).

17. While it is true that the Dean method will minimize the absolute difference in average district size between states for pairwise comparisons, it does not minimize differences in each person's share of a representative. Controlling for average district size ensures equity in the average number of persons represented by each member of the House of Representatives ("one person, one vote" for *intra*-state districts). Controlling for each

person's share of a representative ensures equity in the average number of members of the House that represent each person. It can be argued that the latter is a better test of "one person, one vote" for districts between states since it measures the portion of a vote (member) to which a person is entitled in the House. In any case, both tests can be considered valid tests of the "one person, one vote" principle. The equal proportions method can be shown to be the only method that can simultaneously meet both tests in a proportional, not absolute, sense for pairwise comparisons. The historical arguments for equal proportions were first developed by Professor E. V. Huntington of Harvard in 1921. Huntington showed that equal proportions is the only method that always produces an apportionment with the following properties: Once representatives have been assigned to the states using the equal proportions method, *any* transfer of representatives between two states always will increase the relative difference between the two states' average district size *and* will increase the relative difference between each person's share of a representative for the two states.

18. To illustrate, if the Dean method were used instead of the equal proportions method to allocate seats in the House of Representatives for the 1990 apportionment population, Montana would be allocated two seats instead of one, Washington would be allocated eight seats instead of nine, and all other allocations would be unchanged. With the equal proportions allocations, Montana has an average district size 48.0% larger than Washington, while a Washington resident has an average share of a representative 48.0% higher than a Montana resident. However, if a seat were transferred from Washington to Montana, then Washington would have an average district size 52.1% larger than Montana, and a Montana resident would have an average share of a representative 52.1% higher than a Washington resident. Thus, in relative terms, using the equal proportions

method, Montana is less disadvantaged in comparison with Washington than Washington would be in comparison with Montana if a seat were transferred from Montana to Washington (as would occur using the Dean method).

19. An alternative way of looking at this concept is as follows: With the equal proportions method, the Montana district size of 803,655 would be 40.4% greater than the average United States district size of 572,466. However, if Montana were to receive a second seat (as it would, for example, using Dean's method) then the average United States district size would be 42.5% greater than Montana's average district size of 401,828. Thus, in this respect, Montana's advantage with an allocation of two seats is larger than its disadvantage with one seat. For Washington, the average United States district size is 5.4% larger than Washington's average district size with the equal proportions allocation of nine seats. If Washington were to receive eight seats (as it would, for example, using Dean's method), then Washington's average district size would be 6.7% larger than the United States average. In this respect, Washington's advantage with an allocation of nine seats is smaller than its disadvantage with an allocation of eight seats. The method of equal proportions guarantees that a higher priority is given to awarding a seat to a state that has a smaller advantage in relative terms with the additional seat than its disadvantage without the additional seat, and a lower priority to a state for which the opposite is the case. Consequently, under the equal proportions method, Washington receives a higher priority for a ninth seat than Montana does for a second seat.

20. As noted previously, the Dean method is optimal in a pairwise sense with a different measure of equity. It is the only method for which any transfer of representatives between two states always increases the absolute difference between the two states' average district sizes. Under the Dean method, Montana would receive two seats and

have an average district size of 401,828 while Washington would receive eight seats and have an average district size of 610,993, resulting in a 209,165 difference in absolute value. With an allocation of one seat to Montana and nine to Washington, Montana's average district size would be 803,655 and Washington's would be 543,105, resulting in an increase in the absolute value of the difference to 260,550.

21. In comparison with the use of relative differences, the use of absolute differences between average district sizes as a test tends to give more weight to positive deviations from the national average district size than it does to negative deviations. To illustrate by any artificial example, consider a national average district size of 600,000. Then consider a district size of 1,200,000 and one of 300,000: both have relative differences of 100% from 600,000 and are equally inequitable in relative terms. (That is, in one case the district is twice as large as the ideal, while in the other it is twice as small.) However, in absolute terms, the inequity is greater for the district of size 1,200,000, since it has an absolute difference of 600,000 from the average district size of 600,000 while the district of size 300,000 has an absolute difference of 300,000 from the average district size. In relative terms, any district of size less than 300,000 would present a greater inequity than a district of size 1,200,000. In absolute terms (again, compared to the average of 600,000), a district of size 1,200,000 presents a greater inequity than even a district of size 1 (which has an absolute difference of 599,999).

22. The Adams method is also mentioned by plaintiffs. This method is optimal with respect to absolute representative surplus for the pairwise criterion. However, the authors of the 1929 NAS report considered this measure of inequity more artificial than the measures of inequity for which either the Dean or equal proportions methods are optimal. Furthermore, among the three methods mentioned by plaintiffs, the Adams method is the only one that would have suffered from quota violations

if it had even been used for apportionment. To illustrate the concept of quota, if a fractional number of House seats were allowed, then California's exact, proportional share based on the 1990 apportionment population would be 52.124. Since fractional representation is not permitted, it would appear natural to require that California's number of seats be either rounded down to 52 or up to 53. Any other allocation would be deemed a quota violation. Applying the Adams method to the 1990 apportionment population would only allocate 50 seats to California and would also result in quota violations for Illinois, New York and Ohio. In fact, the use of the Adams method would have resulted in a quota violation for at least one state for every census since 1820, with a total of 47 violations of quota. Although it can be shown that all three methods described by plaintiffs theoretically can violate quota, such violations would not have occurred for any census under the the equal proportions method or the Dean method.

23. In addition to tests which focus on inequity among pairs of states, tests of equity can be devised using various measures of deviation from some definition of "ideal" among all states. The plaintiffs declare that the proper measure of deviation is the absolute population variance between districts and that the Dean methods results in the smallest such variance. This latter claim is incorrect. The variances actually computed as described in Diana Hill's affidavit, were for the average district sizes for the 50 states. This computation failed to take into account the number of districts in each state. A proper formula for computing the variance among the 435 districts is

$$\sum_{i=1}^{50} a_i \left(p_i/a_i - \sum_{j=1}^{50} p_j/435\right)^2/434,$$

where p_i is the population and a_i is the number of seats allocated to the i-th state. With this formula, the variances are 661,230,400 for the equal proportions method, 681,742,400 for the Dean method, and 1,911,200,000 for

the Adams method. Not only does the equal proportions method minimize variance between districts for this particular census among these three methods, but it can be shown mathematically that the equal proportions method minimizes this variance among all apportionment methods and all sets of populations.

24. The plaintiffs also propose a second test for measuring deviation among the 50 states: namely, the range in district size. It is true that both the Adams and the Dean methods produce a smaller range (an absolute number) in district size for the current census than the equal proportions method. However, if relative difference (rather than absolute difference) is accepted as an appropriate measure of inequity, a range test, like the pairwise test associated with the Dean method, tends to give greater weight to large positive deviations from the national average district size than to large negative deviations (see discussion in paragraph 21). An alternative to this test would be to first compute the relative difference between each state's average district size and the national average district size, and then compute the maximum of these relative differences among all 50 states. For the current census, the maximum relative difference is smallest at 40.4% for the equal proportions method, while it is 42.5% for the Dean method, and 78.5% for the Adams method.

25. Attached hereto as Exhibit C is a table which illustrates the number of seats that Montana would receive under each of the six methods discussed in this declaration based on the results of the last four censuses (1960, 1970, 1980, and 1990), given a fixed House size of 435. Under all four methods ever legislated by Congress for use, Montana's apportionment would be one seat for 1990.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Executed on: August 23, 1991

/s/ Lawrence R. Ernst
LAWRENCE R. ERNST

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City College of New York, New York, NY, 1966
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Merit Pay Performance Awards, 1984-90
Bureau of the Census Bronze Medal, 1987
Best presentation award at the American Statistical Association annual meeting, 1978
CUNY Faculty Research Awards, 1972, 1973
Elected to Sigma Xi, 1970
NASA Traineeship, 1966-69
New York State Regents Fellowship, 1966
Elected to Phi Beta Kappa, 1966

Referred Publications:

"Weighting Issues for Longitudinal Household and Family Estimates," *Panel Surveys* (1989) New York; John Wiley, 139-159.

"Maximizing the Overlap Between Surveys when Information is Incomplete," *European Journal of Operational Research* 27 (1986), 192-200.

"Applications of Transportation Theory to Statistical Problems," *Journal of American Statistical Association* 80 (1985), 903-909. (Co-author)

"Controlled Rounding," *INFOR* 20 (1982), 423-432. (Co-author)

"Comparison of Estimators of the Mean Which Adjust for Large Observations," *Sankhva Series C* 42 (1980), 1-16.

"A Gross Measure Property," *Transactions of the American Mathematical Society* 238 (1978), 397-406.

"T Measure of Cartesian Produce Sets II," *Transactions of the American Mathematical Society*, 222 (1976), 211-220.

"A Hausdorffff Measure Inequality," *Transactions of the American Mathematical Society* 219 (1976), 211-220.

"T Measure of Cartesian Product Sets," *Proceedings of the American Mathematical Society* 49 (1975), 199-202.

"A Proof that H^2 and T^2 Are Distinct Measures," *Transactions of the American Mathematical Society* 191 (1974), 363-372.

"A Proof that C^2 and T^2 Are Distinct Measures," *Transactions of the American Mathematical Society* 173 (1972), 501-508.

Other Publications and Presentations:

Includes authorship or co-authorship of 18 papers presented at the annual meetings of the American Statistical Association; presentations at meetings of the American Mathematical Society and the Operations Research Society of America; and presentations at seminar series at the Census Bureau, the Bureau of Labor Statistics, and the National Center for Health Statistics.

SUPREME COURT OF THE UNITED STATES

No. 91-860

UNITED STATES DEPARTMENT OF COMMERCE, ET AL., APPELLANTS

v.

MONTANA, ET AL.

APPEAL from the United States District Court for the District of Montana. The statement of jurisdiction in this case having been submitted and considered by the Court, in this case probable jurisdiction is noted. The motion of appellees for expedited briefing schedule and oral argument is granted. The opening brief of appellants is to be filed with the Clerk on or before January 15, 1992. The brief of the appellees is to be filed with the Clerk on or before February 12, 1992. The reply brief of appellants is to be filed with the Clerk on or before February 21, 1992. The case is set for oral argument during the Session beginning February 24, 1992.

December 16, 1991

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